Translation

EP 1 029 651 A1, Published 8/23/2000

Process for Producing Three-Dimensional Objects by Means of Stereolithography

A process for producing three-dimensional objects by means of stereolithography, in which a laser cures predetermined areas of a continuously subsequent resin bath, whereby before or during the laser exposure the physical and/or mechanical properties of the object to be produced are added or generated and a resin/particle mixture is formed and that the laser exposure causes the particles to be integrated into the cured resin and/or a bond is created between the particles and the resin and/or among the particles.

Translation

EP 1 029 651 A1, Published 8/23/2000

Description

Technical Field

[0001] In the last years, a technology that first designs three-dimensional objects with the aid of CAD software and then produces the objects with stereolithography has become widespread. Using laser light, predetermined areas of continuously new subsequent layers of a resin bath are cured.

State-of-the-Art

[0002] Stereolithography to-date has been limited to the production of viewable and design models. Curing has been done using an ultraviolet laser which passes over a basin with liquid resin, curing it at predetermined points. The objects produced are used as visual models, for example, to demonstrate their ease of installation with neighboring parts. The objects have a relatively low degree of hardness and their use is limited to the purpose specified.

[0003] The task of the invention described herein is, therefore, to improve the process mentioned above so that it is possible to produce objects with properties not previously achieved, e.g. with increased strength, heat conductivity, specially formed surfaces, and the like.

[0004] The solution of this task is achieved with a process for producing three-dimensional objects using stereolithography, in which a laser continuously cures specific areas of continuous layers of a resin bath, such that before or during the laser exposure the physical and/or mechanical properties of the object to be produced are added or generated and a resin/particle mixture is formed and that the laser exposure causes the particles to be integrated into the cured resin and/or a bond is created between the particles and the resin and/or among the particles.

[0005] The formation of the particles and their adding can be varied over wide areas. Thus, it is fundamentally possible to add the particles to the resin bath in solid and/or liquid form and or gaseous form and to distribute them therein. Here, the particles themselves can be modified in nearly any fashion. For example, liquid or solid particles can be used that have gas bubbles on their surface or inside. In this way, insulating properties can be achieved. The same application can be served by particles that are converted to gas form when exposed to laser, whereby cavities are created in the produced object. The introduction of particles made of nano-material is also sensible, e.g. in the form of nano-metal or nano-liquids, especially if properties resulting from the metal are to be achieved, e.g. a high conductivity (electrical, magnetic or heat).

[0006] A high level of heat conductivity can be attained, for example, if liquid resin particles are introduced preferentially, which when cured lead to a high conductivity. When they are introduced, the liquid resin particles can be covered with a separating layer that inhibits their solubility in the resin bath itself.

[0007] Good results can also be achieved if the introduced particles have been covered with a layer that activates their bond to the resin and/or each other, preferably with a liquid. Thus, it is possible to encase the particles in a material that can be laser sintered and to add them in a high concentration or agglomerated to a resin bath.

[0008] In case the most even distribution of particles in the resin bath needs to be achieved, the resin bath/particle mixture can be subjected to ultrasound. This leads to the desired even distribution or maintains this condition.
[0009] A preferred execution of this process foresees the surface of the particles being activated before they are added to the resin bath. This activation may be done in different ways. For example, the particles made of a plastic can be subjected to plasma activation. Particle made of a metal or metal compound can usually be subjected to chemical activation. This activation can also be achieved using specific nano-materials, preferably in liquid form.
[0010] In the case of many objects, it is advantageous for certain parts of the object to demonstrate special properties, e.g. when a high level of heat conductivity or anti-soiling properties are required of the surface. In these cases, the particles can be added selectively, to achieve a greater concentration or particles in the respective part of the objects. This selective adding of particles is achieved in a manner similar to ink-jet or screen printing technology. It is also possible to subject metal particles to electromagnetic alignment when the resin is in a non-cured state.
[0011] In selected cases, it can be advantageous for the resin bath to be subjected to laser exposure twice immediately in succession, where the first exposure is done with reduced energy. This is suitable, for example, when the particles has been introduced to the resin bath in gaseous form. Here, the energy reduced initial laser beam increases the temperature of the mixture and the gas particles expand. The directly following normal laser exposure produces the final cureing. However, it is also possible to dissolve the gas particles in the resin bath and to transform them into gas bubbles at least partially with the initial laser beam. The size of the gas bubbles can be determined with the intensity and duration of the laser exposure.
[0012] A special benefit of the objects produced with the process described above is that they can be recycled. They can be separated back to their original materials. Recycling treatment can be used in which the object is ground using liquid nitrogen and the resin and the particles are sorted.

Examples:

[0013] the production of a finished product, e.g. an artistically designed paperweight can be done as follows: A bath is produced from a resin to which titanium power particles are added. A resin bath/titanium powder mixture is formed. The paperweight is formed from this mixture using stereolithography. The titanium particles are bound in the cured resin and the paperweight is comparable with a paperweight produced from pure titanium with regard to appearance, gloss, weight, etc. Other objects with the desired properties can be produced in the same manner by adding other particles. The stereolithography processes considered to be state-of-the-art were not suitable for producing such products.
[0014] With the new process, it is also possible to produce tool parts without the intermediate step of a casting form. To produce such tool parts, a bath is first made from a resin. The particles are introduced to this bath which will provide the tool part with a high level of compression

strength when cured. For example, the particles can be made of a metal and be used in the form of metal powder. A resin bath/metal particle mixture is made and a base form is produced using stereolithography. The external shape of the base form is such that it can be placed in a corresponding tool frame or be provided with a reinforcement. Channels can be introduced in the base form using stereolithography to dissipate the excess heat generated in later production or add necessary heat. The interior surfaces of the tool part, which represent the limit of the finished injection molded product, can also be provided with added particles to achieve a special surface quality.

[0015] In this manner, for example, PTFE powder or a nano-fluid with a fluoridated side group can be added to produce a low tendency to fouling. This powder or nano-material is bound into the resin, producing the desired surface. Moreover, the tendency to wear can be reduced on a specific section of the tool part, e.g. on its edges, by adding a metal powder resin to this section. The tool part produced in this manner can be used directly for series production of an object.

Patent Claims

1. A process for the production of three-dimensional objects by means of stereolithography, in which a laser cures continuously subsequent layers of a resin bath, distinguished by the fact that before or during the laser exposure the physical and/or mechanical properties of the object to be produced are added or generated and a resin/particle mixture is formed and that the laser exposure causes the particles to be integrated into the cured resin and/or a bond is created between the particles and the resin and/or among the particles.

2. A process in accordance with Claim 1, distinguished by the fact that the particles are added to the resin bath and are distributed in it in solid and/or liquid and/or gaseous form.

3. A process in accordance with Claims 1 or 2, distinguished by the fact that the surface or the inside of the particles in solid or liquid form are provided with gas bubbles.

4. A process in accordance with Claim 1, distinguished by the fact that the particles are converted into gaseous form by means of the laser acting upon them.

5. A process in accordance with one or Claims 1 or 2, distinguished by the fact that the particles made of nano-material are introduced in the form of nano-metals or nano-fluids.

6. A process in accordance with Claims 1 to 5, distinguished by the fact that the preferably liquid particles are coated with a separating layer that inhibits their solubility in the resin bath.

Translation

EP 1 029 651 A1, Published 8/23/2000

7. A process in accordance with one of the claims 1 to 5, distinguished by the fact that the particles are coated with a layer, preferably with a liquid, that activates their bond to the resin and/or among one another.

8. A process in accordance with one of Claims 1 to 5, distinguished by the fact that the particles are added to the resin bath in a high concentration or agglomerate encased in a material that can be laser-sintered.

9. A process in accordance with one of Claims 1 to 8, distinguished by the fact that the resin bath/particle mixture is subjected to ultrasound, in order to achieve even distribution of the particles in the resin bath.

10. A process in accordance with Claims 1 to 8, distinguished by the fact that the surface of the particles is activated before they are added to the resin bath.

11. A process in accordance with one of Claims 1 to 9, distinguished by the fact that a particle made of plastic is subjected to plasma activation.

12. A process in accordance with Claim 10, distinguished by the fact that particles consisting of metal or a metal compound are subjected to chemical activation.

13. A process in accordance with Claim 10, distinguished by the fact that the particles are activated by nano-materials, especially in liquid form.

14. A process in accordance with one of Claims 1 to 13, distinguished by the fact that the particles are added selectively.

15. A process in accordance with Claim 14, distinguished by the fact that the selective addition of the particles is done in a manner similar to ink-jet and/or screen printing technology.

16. A process in accordance with one of Claims 1 to 13, distinguished by the fact that particles with magnetic properties, especially made of metal, are subjected to magnetic alignment when the resin bath is in an uncured state.

17. A process in accordance with one of Claims 1 to 16, distinguished by the fact that the resin bath/particle mixture is subjected to two directly subsequent laser exposures, where the first is performed with reduced energy.

18. An object produced in accordance with the processes in Claims 1 to 17, distinguished by the fact that the object can be recycled.

19. An object in accordance with Claim 18, distinguished by the fact that the recycling treatment is performed by grinding the object using liquid nitrogen and then sorting the resin and the particles.